# SCANNING FORCE MICROSCOPE WITH INTEGRATED OPTICS AND CANTILEVER MOUNT

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to scanning force microscopes, and more particularly concerns a scanning force microscope with an improved optical lever arm and integrated optics for viewing the lever arm and a sample.

2. Description of Related Art

Scanning force microscopes, also known as atomic force microscopes, are useful for imaging objects as small as atoms. The scanning force microscope is closely related to the scanning tunneling microscope and the technique of stylus profilometry, however in a typical scanning force microscope, deflection of a laser beam by a vertical movement of a probe following the contours of a specimen is amplified by a reflective lever arm to which the probe is mounted. The deflection of the laser beam is typically monitored by a photodetector in the optical path of the deflected laser beam, and the sample is mounted on a stage moveable in minute distances in three dimensions so that the sample can be raster scanned while the vertical positioning of the probe relative to the surface of the sample is maintained substantially constant by a feedback loop with the photodetector controlling the vertical positioning of the sample.

As the sensitivity of the optical lever arm and probe are crucial to the useful operation of such scanning force microscopes, conventional scanning force microscopes generally include optical lever arms of such small dimensions that the optical lever arms and probe assembly can easily be damaged by contact with a sample or during handling, and the optical lever arms and probe assembly is further difficult to handle and mount in the instrument. It would therefore be desirable to provide an improved mount for the probe, which would be easier to handle and position in the instrument.

While a probe can be damaged by too abrupt an approach to a sample before the probe is close enough to the sample to initiate feedback position control, the user typically can not easily view the approach of the lever arm and probe assembly to the surface of the sample to insure precise positioning of the probe. Even where an optical microscope is used in conjunction with the scanning force microscope to view the sample, the arrangement of the optical microscope with the scanning force microscope can be inconvenient and clumsy, and can interfere with the operation of the scanning force microscope. It would therefore also be desirable to provide a scanning force microscope with optics integrated into the scanning force microscope for viewing the optical lever arm and probe, particularly as the probe and sample come in contact.

It would also be desirable to provide a scanning force microscope with the capability of scanning a sample in contact with a fluid, as such a fluid environment can significantly change scanning conditions and opportunities, and can improve the quality of the image of the sample acquired by the instrument. The present invention meets these needs.

## SUMMARY OF THE INVENTION

Briefly, and in general terms, the present invention provides for a scanning force microscope with integrated optics for viewing the optical lever arm, probe and sample to be examined. The stability and convenience of such integrated optics significantly improve the ability to control the approach of the probe and sample. Additionally, the compact design of the microscope minimizes the effects of thermal expansion and contraction due to thermal gradients or drift in the vicinity of the instrument. The scanning force microscope further includes an improved mount for the probe, which is magnetically secured to the body of the scanning force microscope, to improve ease of handling and mounting the probe assembly. The scanning force microscope of the invention in one preferred embodiment also includes a removable base portion which can contain a fluid cell for receiving a sample and a fluid environment and having a stage upon which the sample can be mounted for scanning the sample in three dimensions relative to the probe tip.

The invention accordingly provides for a scanning force microscope having a stationary body with integrated optics for examining surface contours of a specimen. The microscope preferably includes scanning means to mount and scan the specimen to be examined in three dimensions or degrees of freedom relative to the body of the microscope, and a reflective optical lever arm means including probe means, secured to the microscope body. The probe means is preferably secured to the optical lever arm means and includes a probe tip to contact and follow the surface contours of the specimen with a substantially constant amount of force.

A laser light source means is also provided in the body of the microscope for producing a focused laser beam directed at and deflected by the optical lever arm means, and photodetector means is provided in the body of the microscope to receive the deflected laser beam and to produce an output signal indicative of the degree of deflection of the laser beam by the optical lever arm means. Means for viewing the optical lever arm, probe means, and an adjacent specimen are also preferably provided in the body of the microscope. In one preferred aspect of the invention, the means for viewing comprises an accessory objective lens mounted in the body of the microscope, although the means for viewing may alternatively also include a charge couple device or miniature video camera.

The optical lever arm means preferably includes a reflective cantilever arm having a free end to which the probe tip is mounted, and the optical lever arm means is preferably magnetically secured to the body. The photodetector means preferably includes a photodetector mounted to the body, and mirror means mounted within the body to deflect the laser beam from the optical lever arm means to the photodetector. Control means are also preferably provided for maintaining a constant force of the probe means against the surface contours of the specimen. The body of the microscope also includes a removable base portion having a chamber for receiving the specimen, and in a preferred alternate embodiment includes a sealed cell for containing the specimen in a selected gas or liquid environment.

These and other aspects and advantages of the invention will become apparent from the following detailed description, and the accompanying drawing, which